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Additions to the Rust Fungi of Hawai'i[1]

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ABSTRACT: In a 1989 publication, the 74 species of rust fungi (order Uredinales) known to occur in Hawai'i were listed, based on newly collected material; herbarium specimens, principally those at the Bernice P. Bishop Museum (BISH); and information provided by F. L. Stevens in his 1925 publication on Hawaiian fungi. Stevens had noted an underrepresentation of this group in Hawai'i, which he attributed to the archipelago's isolation from continental landmasses. Since the time of the 1989 publication, 16 additional rusts have been recognized in Hawai'i. These include both recently introduced species, such as *Coleosporium plumeriae* Pat. on plumeria, and those recently discovered, such as *Puccinia rugispora* Gardner and *P. rutainsularа* Gardner on endemic Rutaceae. New host and location records and other important updating information on this well-defined group of fungi in Hawai'i are also included.

THE RUST FUNGI (order Uredinales) constitute a relatively homogeneous group of obligate plant parasites, recognized by the production of morphologically characteristic, primarily windborne spores (Littlefield 1981, Cummins and Hiratsuka 1983). As a group, these fungi are noted for their virulence, causing great losses to crops on a worldwide basis, as well as for their host specificity. Perhaps the most striking characteristic of the rust fungi is the complex life cycle, which may include as many as five different spore states among macrocyclic species. Furthermore, heterocyclic rusts produce some spore states on "primary" and some on "secondary" hosts. Designation of primary and secondary hosts is an arbitrary function of the relative importance, usually economic, of each host rather than of the particular spore states produced on that host. Notwithstanding the host-specificity of the rusts, alternate hosts typically have no taxonomic relationship to one another, with an angiosperm and a gymnosperm or a dicot and a monocot often serving as alternate hosts for a given species. With such wide diversity of hosts, determination of life cycles has presented substantial challenges. Life cycle connections for many spore states remain unconfirmed, leading to the erection of form genera, such as *Uredo,* to accommodate particular spore states of rusts with incompletely known life cycles.

In light of the above generality, it is noteworthy that few of the native or nonnative rusts in Hawai'i exhibit macrocyclic life cycles, but occur in demicyclic or microcyclic form, or as species of *Uredo,* in which only the uredinial state is known. Furthermore, use of alternate hosts as described above is not known to occur among either native or nonnative rusts in Hawai'i. Species that use alternate hosts to complete their life cycles elsewhere are limited to a single host in Hawai'i. For example, the aecial state of *Uredinopsis hashiokai* causes a serious needle disease of species of fir (the primary host) in western North America (Faull 1938, Ziller 1959), but the rust occurs in Hawai'i only in the uredinial state on the secondary host, bracken fern (*Pteridium aquilinum*). The "repeating" ability of the uredinial state enables otherwise long-cycled rusts to survive indefinitely in tropical environments where a resistant resting, or overwintering, state is not required.

In an earlier publication, Gardner and Hodges (1989) listed the rust fungi known to occur in Hawai'i, based largely on specimens on deposit at the B. P. Bishop Museum (BISH), the Animal

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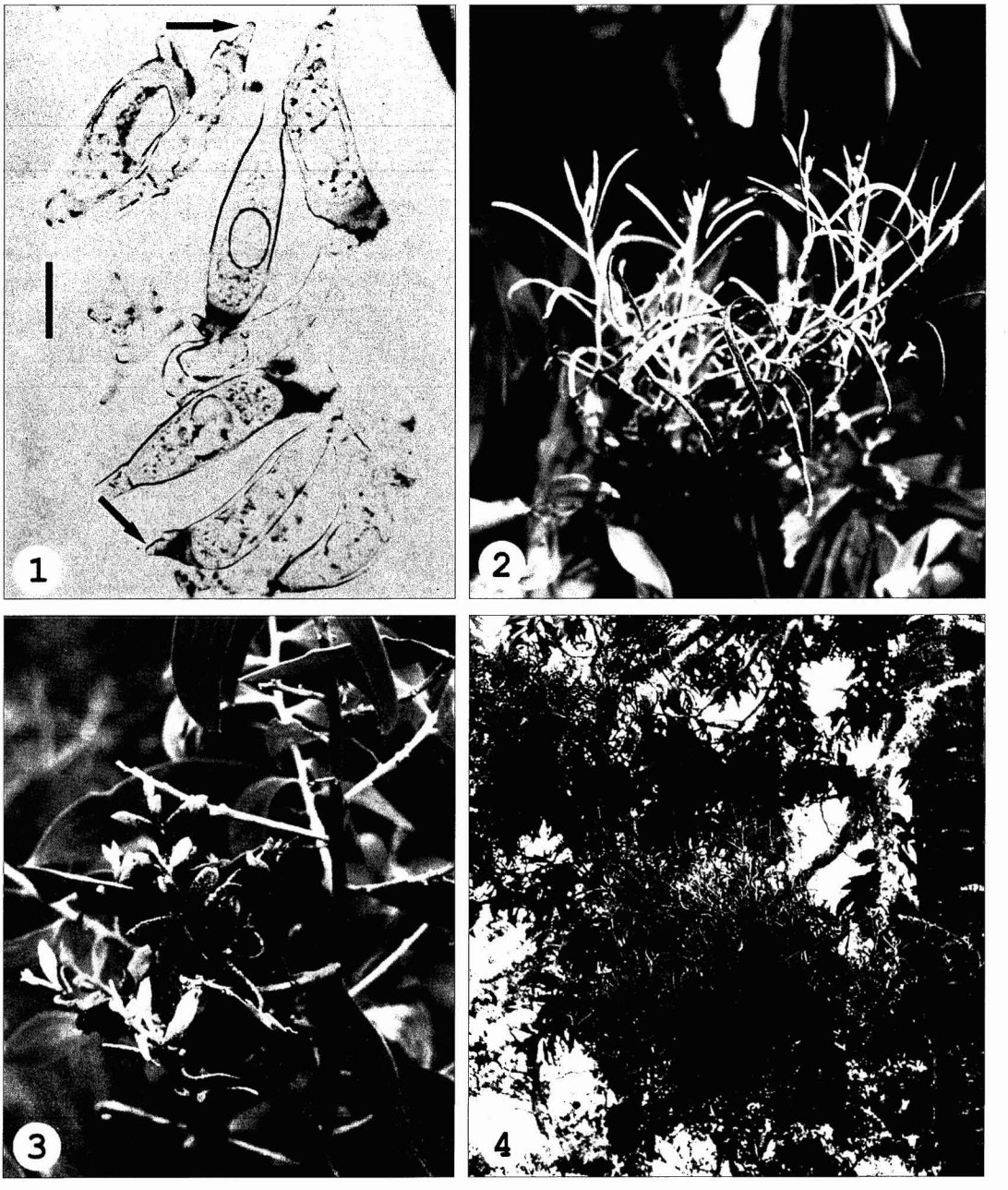
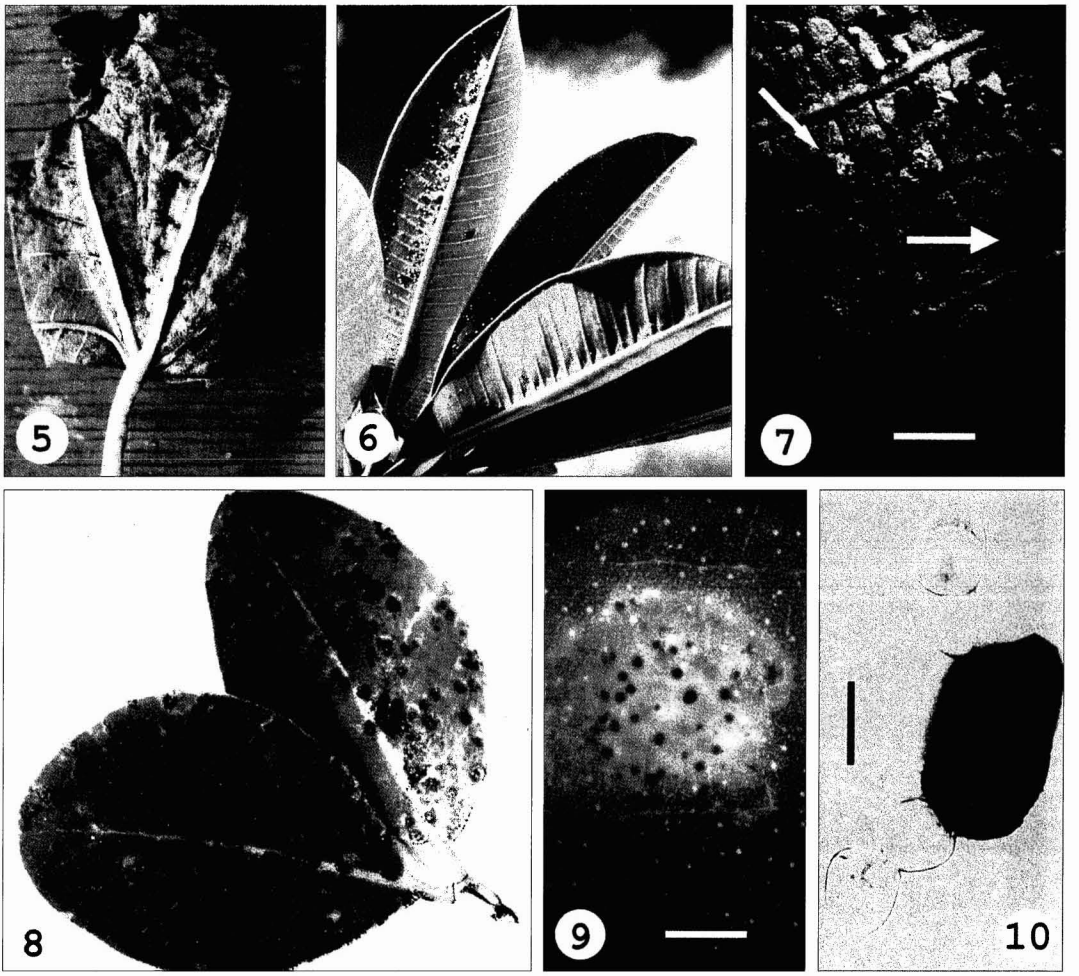
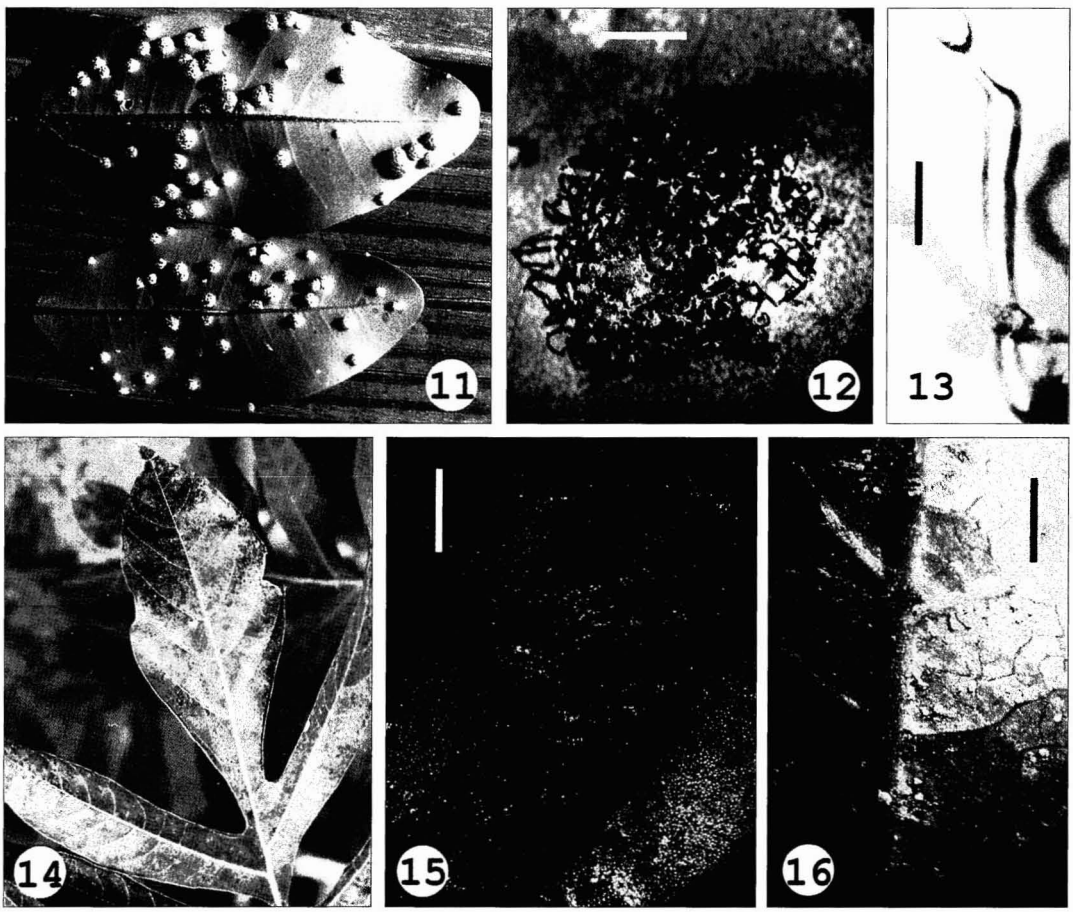


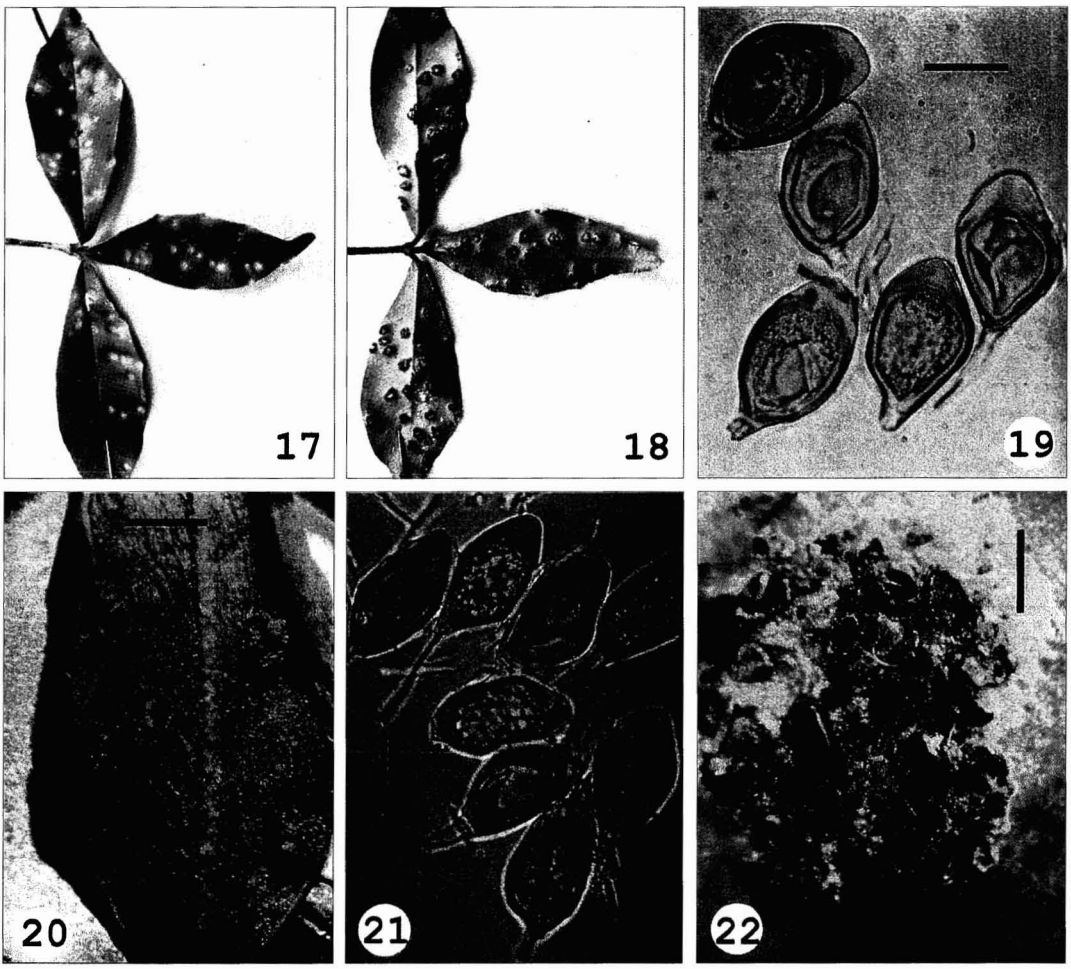
PLATES 1–4. Koa rusts, *Atelocauda* spp. on *Acacia koa.* (1) Teliospores of *A. angustiphylloda,* which are identical to those of *A. digitata.* Note the irregular digitate processes of apical thickenings (arrows) from which the specific name is derived; scale = 18 µm. (2) Young telial witches'-broom of *A. angustiphylloda.* (3) Spermogonial-aecial broom of *A. digitata.* (4) Large, mature brooms of *A. angustiphylloda* in an older tree.



PLATES 5–10. Rusts of fig, plumeria, and *Zanthoxylum.* (5) Fig rust *(Cerotelium fici).* Undersurface of a desiccated leaf covered with minute uredinial pustules. (6–7) Plumeria rust *(Coleosporium plumeriae).* (6) Uredinial pustules on leaf undersurfaces. (7) Closeup of uredinial (small arrow) and telial (large arrow) pustules on leaf undersurface; scale = 2 mm. (8–10) *Zanthoxylum* rust *(Puccinia rugispora).* (8) Upper surfaces of leaves heavily infected with telial pustules. (9) Cluster of immature, pre-emergent telia developing within leaf tissue; scale = 2 mm. (10) Teliospore germinating to produce two globoid structures from each cell; scale = 20 μm.



PLATES 11–16. Rusts of *Melicope,* breadfruit, naio, and *Coprosma.* (11–13) *Melicope* rust *(Puccinia rutainsulara).* (11) Prominent gall-like telial pustules on under surfaces of *M. anisata* (mokihana) leaves. (12) Closeup of exuded hairlike columns of teliospores; scale = 2 mm. (13) Typical teliospore germination behavior of *P. rutainsulara* in which a basidium bearing a single basidiospore is produced; scale = 25 µm. (14) Breadfruit leaf with russeting symptom associated with numerous minute uredinia of rust *(Uredo artocarpi).* (15) Naio leaf with uredinial pustules of *Uredo myopori* on the undersurface. The rust is associated with reddish pigmentation of infected tissue, later often becoming nectrotic; scale = 4 mm. (16) *Coprosma* leaf with minute, yellow uredinial pustules of *Uredo vulcani* on the undersurface; scale = 2 mm.



PLATES 17–22. *Alyxia* rusts. (17–18) *Uromyces alyxiae* var. *alyxiae* on leaves of Hawaiian maile. (17) Upper leaf surface with chlorotic, sunken spots. (18) Corresponding telial pustules on lower surfaces. (19–20) *U. alyxiae* var. *australiensis* on *A. ruscifolia* from Queensland, Australia. (19) Teliospores; scale = 15 µm. (20) Individual telial pustules on a leaf undersurface; scale = 7 mm. (21–22) *U. alyxiae* var. *alyxiae*. (21) Teliospores; scale = 15 µm. (22) Cluster of telia on leaf undersurface; scale = 0.5 mm.

and Plant Health Inspection Service collection at Honolulu International Airport (HONQ), the fungus collection of the Department of Botany, University of Hawai'i at Mānoa (HAW), and the work of F. L. Stevens, who, in his comprehensive treatment of Hawaiian fungi (Stevens 1925), devoted special attention to the rusts. Stevens noted that the Uredinales as a group were poorly represented in Hawai'i in comparison with those found in other insular regions. He attributed this to the extreme isolation of the Hawaiian Islands rather than to any intrinsic environmental factor that may be unfavorable to rust fungi. More recently, Gardner (1994*a*) documented species thought to be native to Hawai'i, including those discovered since Stevens' work, but affirmed Stevens' observation of the relative scarcity of rusts in this region, with little likelihood that a large number of species remains to be found. Occasional new introductions to the Islands, such as noted below with plumeria rust, may occur from time to time. Most species listed below, however, are considered to have been present in Hawai'i longer than their recent discovery would indicate, but had been previously overlooked.

It was desirable to document those rusts that have been confirmed to occur in Hawai'i since the 1989 publication, including other updating information on species previously reported. Although some of these recent discoveries have been noted individually elsewhere as referenced, it is useful to report them in a single compilation where they can be readily accessed. The standard Roman numeral designations for the spore states of Uredinales are used: 0 = spermogonial, I = aecial, II = uredinial, III = telial, IV = basidial. As noted, most specimens were deposited at BISH or the National Fungus Collection (BPI) at Beltsville, Maryland. Those collected on Kaua'i by Tim Flynn (TF) were deposited in the herbarium of the National Tropical Botanical Garden (PTBG), Lāwa'i, Kaua'i. For species of which a number of herbarium collections are available, only packet numbers for representative specimens are provided.

The following 16 species were not included, or did not appear as such, in the earlier compilation of Gardner and Hodges (1989):

Atelocauda angustiphylloda Gardner
Plates 1, 2, 4

Mycologia 83:650, 1991; 0 and III, on *Acacia koa* (koa). BISH 511352, 1982; 580196–8, 1990.

This rust, which produces only spermogonia and telia, previously was referred to as the microcyclic form of *Atelocauda digitata* (Wint.) Cumm. & Hirat.; the teliospores of the two forms are morphologically indistinguishable from one another (Gardner and Hodges 1989) (Plate 1). Although *A. digitata* occurs as an indigenous species in Hawai'i, having been reported also in Australia (McAlpine 1906), *A. angustiphylloda* appears to be endemic to Hawai'i, where its life cycle is independent from that of *A. digitata,* justifying its recognition as a separate species (Hodges and Gardner 1984, Gardner 1991*a*). The two species also may be distinguished by the morphology of the witches'-brooms that each produces, with brooms (telial) of *A. angustiphylloda* consisting of much-narrowed, linearly shaped phyllodes that may be almost circular in cross section (Plate 2). Brooms (spermogonial-aecial) of *A. digitata* appear abnormally compact because of internodal shortening; phyllodes are short, thickened, and fleshy but usually somewhat flattened in cross section (Plate 3). *Atelocauda angustiphylloda* is limited in distribution as compared with *A. digitata,* being known only on the previously recognized variety *A. koa* var. *latifolia* in certain upper-elevation (>1250 m) forests on the island of Hawai'i. In those sites, however, infection may be severe, with older trees sometimes bearing hundreds of witches'-brooms, some as large as 1 m or more in length (Plate 4). Brooms of both species are covered by powdery brown spore masses at maturity.

Cerotelium fici (Butl.) Arth.
Plate 5

Bull. Torrey Bot. Club 44:509, 1917; II, on *Ficus carica* (common fig). BISH 560938–9, 1990.

Although the date of introduction of *C. fici* to Hawai'i is not known, unpublished records of it exist in the files of the University of Hawai'i Plant Disease Clinic under the names *Physopella fici* (Cast.) Arth. or *Phakopsora fici* (Butl.) Buri-

ticá & Hennen from the late 1960s. McKenzie (1986) first reported this species in New Zealand in 1986 and provided a description of the associated disease, which closely resembles that in Hawai'i. The rust is known only in the uredinial state in both locations, in agreement with the statement of Arthur (1962): "The genus [*Cerotelium*] is largely tropical. . . . The uredi[ni]a are usually the only form collected, the telia being inconspicuous and less often present." The rust may be found wherever fig is cultivated on all major Islands, with masses of pale yellow uredinia visible on lower leaf surfaces. Irregular, coalescing necrotic spots are produced on upper leaf surfaces corresponding to uredinial clusters. Infection may lead to marginal necrosis or general leaf necrosis and up to 100% defoliation, particularly during the winter months and other periods of high humidity (Plate 5). Uredinia may also occur on fruit, where they produce necrotic spots 1–3 mm in diameter.

Coleosporium plumeriae Pat.
Plates 6, 7

Bull. Soc. Mycol. Fr. 18:178, 1902; II and III, on *Plumeria obtusa* (Singapore plumeria) and *P. rubra* (red plumeria) on all major Islands. BISH 641407, 1991.

The plumeria rust fungus, also known as *C. domingense* (Berk.) Arth. (Arthur 1962), was introduced to Hawai'i relatively recently, being first found on O'ahu in January 1991 (Ogata and Gardner 1992). The circumstances of its introduction are not known, but it may have arrived on infected plant material from Florida or southern Texas where it is known to occur. It has since spread to all major Islands, where it can defoliate red plumeria. Singapore plumeria is relatively resistent to infection. Bright yellow-orange, powdery-appearing uredinia may cover the undersurfaces of leaves of susceptible plants (Plate 6) and on heavily infected leaves may also emerge in smaller numbers on the upper surface. Darker orange-brown, waxy-appearing telia are later produced among the uredinia (Plate 7). Although the spermogonial and aecial states of other species of *Coleosporium* occur on species of pine, an alternate host for *C. plumeriae* has not yet been found at any location where this rust occurs (Traquair and Kokko 1980).

Desmella aneimiae Syd.

Ann. Mycol. 16:241, 1918; II, on *Christella* (= *Thelyptris*) *dentata* (downy wood fern, pai'i'-iha). BISH 644615; BPI 737878; TF 5982 (all 1996).

The host occurs throughout warmer and temperate regions of the world and is one of the most common ferns in Hawai'i, where it was introduced about 1887 (Valier 1995). *Desmella aneimiae* recently was discovered in the Ku'ia Natural Area Reserve, Mahanaloa Valley, Kaua'i, where the uredinial state was sufficiently abundant to impart an orange-yellow cast to stands of the host. This discovery probably resolves questions concerning collection of a yellow-spored rust on this host in 1991 by a visiting scientist, Roger Peterson, on Kuilau Ridge Trail near Keāhua Arboretum, Kaua'i. The collection was later deposited at BISH (641405) with the tentative name *Hyalopsora* sp. *Desmella* and *Hyalopsora* are distinguished from the genus *Uredinopsis,* which also occurs on ferns in Hawai'i (as *U. hashiokai* Hirat. f.) (Gardner and Hodges 1989), by yellow pigmentation of the urediniospores of the former genera. *Uredinopsis* is considered perhaps the most primitive of all rust genera because it lacks pigmentation (Cummins and Hiratsuka 1983). The pigmentation of urediniospores of *Hyalopsora* may be faint and is limited to the spore contents, with the spore wall colorless, whereas with *Desmella* the spore wall, as well as the contents, are usually pigmented, at least when fresh. The genus *Desmella* is incompletely known, but is currently thought to be represented by a single species, *D. aneimiae* (J. Hennen, pers. comm.), notwithstanding earlier mention of three or four species (Cummins and Hiratsuka 1983). The life cycle of *D. aneimiae* is not known, but mode of infection is unusual, being limited to substomatal chambers of the host, with uredinia and telia (when present) emerging through the stomata. The fungus is therefore evident as suprastomatal clusters of spores, rather than subepidermal uredinial pustules from which the urediniospores are released at maturity through ostioles or ruptured epidermis, as occurs with other rusts, including *Hyalopsora.*

Melampsora monticola Mains

Phytopathology 7:103, 1917; II and III, on *Euphorbia peplus* (petty spurge). TF 3917, 1990.

The host is an annual herbaceous pasture weed from Eurasia that has become naturalized in Hawai'i and occurs in disturbed areas, particularly pastures (Wagner et al. 1990). However, the collection cited here was found in the 'Ōla'a rain forest of Hawai'i Volcanoes National Park. The uredinial state of the rust is evident when fresh as conspicuous bright orange pustules on both leaf surfaces of the host. In contrast, the telia are inconspicuous, remaining subepidermal and nonerumpent. They are visible as blackish brown discolored spots in the vicinity of the uredinia. The prismatic teliospores form a uniform layer, adhering to one another laterally. With the earlier recognition of *Uredo wikstroemiae* (Arth. in Stevens) Hirat. as a species of *Melampsora* (Gardner 1988), *M. monticola* is the second representative, although not native, of this genus in Hawai'i. It is notable that *M. monticola* is also the only rust in Hawai'i known to produce subepidermal nonerumpent telia.

Phakopsora sp.

II, on *Glycine max* (soybean). BISH 641406, 641410, 1994.

The recent discovery of a highly destructive rust of soybean on O'ahu was the cause of some alarm among state and federal agricultural agencies because the rust was thought to have been newly introduced to Hawai'i, and efforts were begun to attempt to eradiciate it. However, its subsequent discovery on other Islands indicated that the pathogen was more widely established than was at first realized (Killgore et al. 1994). The virulent nature of the rust in Hawai'i suggests that the rust is *P. pachyrhizi* H. & P. Sydow; Ann. Mycol. 12:108, 1914, a species of Asian origin (J. Hennen, pers. comm.). However, in the absence of the telial state, the rust cannot be distinguished morphologically from a second species reported to attack soybean, *P. miebomiae* (Arth.) Arth.; Bull. Torrey Bot. Club 44:509, 1917, which is thought to have originated in the Western Hemisphere and to be less virulent on this host (Ono et al. 1992). Binomials for the anamorphic states of these two species have been proposed: *Malupa sojae* (P. Hennings) Ono, Buriticá & Hennen for *P. pachyrhizi*; and *M. vignae* (Bresadola) Ono, Buriticá & Hennen for *P. miebomiae* (Ono et al. 1992).

Puccinia cnici Mart.

Fl. Mosq. 226, 1817; II and III, on *Cirsium vulgare* (bull thistle). BISH 590221–2, 1990.

Bull thistle is a spiny pasture weed of Eurasian origin first recorded in Hawai'i in 1909 and now naturalized on all of the main Islands (Wester 1992). Severe infection with *P. cnici,* which may cause necrosis of the lower leaves, is accompanied by conspicuous masses of brown uredinia on both leaf surfaces. Darker brown to black telia often are intermixed with the uredinia. Although *P. cnici* is reported as a macrocyclic, autoecious rust elsewhere (i.e., with all spore states occurring on the same host species) (Cummins 1978), spermogonia and aecia have not been found in Hawai'i.

Puccinia crepidis-montanae (Syd.) Magn.

Beitr. Kryptogamenflora Schweiz 2:212, 1904; II, on *Youngia japonica* (Oriental hawksbeard). BISH 612840, 614102, 1991.

Oriental hawksbeard is a low-growing, annual herb native to southeastern Asia. It was first recorded in Hawai'i in 1865 and has become naturalized as a common weed in moist, shaded habitats on most major Islands (Wester 1992). The rust occurs as cinnamon-brown uredinial pustules on the leaf undersurfaces, with corresponding chlorotic spots on upper surfaces. Leaves may be heavily infected. The rust is probably common and as widespread as is its host in Hawai'i but has not previously been reported, possibly because of an apparent seasonality or sensitivity to moisture conditions that limit its appearance. Spermogonia, aecia, and telia have been reported on related host species elsewhere (Arthur 1962). The collections from O'ahu and Kaua'i (TF 5972) contain only uredinia, but the eventual discovery of telia of this rust would not be unexpected.

Puccinia iridis (Wallr.) Raben.

Deuts. Kryptogamenflora-Fl., 1844; II, on *Belamcanda chinensis* (blackberry lily, leopard lily, paradanthus). TF 5834, 1996.

Although the common names suggest an affiliation to the Liliaceae family, the host is an ornamental introduction of the Iridaceae from eastern Asia. The uredinial and telial states of the rust occur on a number of iridaceous hosts throughout North America and Asia (Arthur 1962, Hiratsuka et al. 1992), but only the uredinia are known currently in Hawai'i. A similar rust, *P. belamcandae* Diet., on *B. chinensis* in Japan, China, and India, is the species with which *P. iridis* might most readily be compared (Hiratsuka et al. 1992). The rust in Hawai'i has smaller (25–32 by 20–26 μm), ochraceous brown urediniospores with approximately linearly arranged germ pores as compared with *P. belamcandae,* which has larger (23–40 by 20–35 μm), yellow to dark brown urediniospores with scattered germ pores. Rust pustules of *P. iridis* occur on both leaf surfaces, whereas those of *P. belamcandae* are limited to the upper surface (Hiratsuka et al. 1992). Characteristics of the teliospores, which eventually may be found in Hawai'i, would add further distinction.

Puccinia menthae Pers.

Synth. Methods Fung. 1801:227; II and III, on *Mentha spicata* (spearmint). BISH 612839, 1991.

Spearmint is a widely cultivated aromatic herb that has become naturalized in Hawai'i. Although *P. menthae* is known to be macrocyclic and autoecious, occurring on a large number of genera of the family Lamiaceae throughout the world (Baxter 1959), only the uredinial and telial states have been found on the host in moist, shady sites of Kīpuka Puaulu in Hawai'i Volcanoes National Park. The rust is probably not as rare as the single, relatively recent collection would indicate, and eventual discovery on other mint species elsewhere in Hawai'i would not be unexpected.

Puccinia rugispora Gardner
Plates 8–10

Mycologia 82:141, 1990; III, on *Zanthoxylum dipetalum* (kāwa'u). BISH 612841–3, 1990–1991.

Puccinia rugispora recently was discovered and described as a new, microcyclic species considered endemic to Hawai'i (Marr and Gardner 1989, Gardner 1990). It has been found only on a few trees of its endemic host in the region of Kōke'e State Park, Kaua'i. Notwithstanding its apparent rare status, leaves of susceptible trees may be heavily infected (Plate 8). Numerous conspicuous clusters of deeply immersed telia (Plate 9) open through slitlike pores and expel teliospores on the leaf surface when mature. As with other endemic Hawaiian rusts, teliospores of *P. rugispora* exhibit unusual nuclear and germination behavior (Gardner 1996). In contrast to the elongate, hyphal-like basidium produced by most rusts, teliospores of *P. rugispora* germinate to produce two globoid, vessiclelike structures in succession from each cell (Plate 10), each capable of producing a sterigma and a basidiospore. The diploid nucleus resulting from karyogamy in the teliospore divides mitotically to produce two or more daughter diploid nuclei. Meiosis occurs in or near the developing basidiospore, resulting in a tetranucleate basidiospore.

Puccinia rutainsularа Gardner
Plates 11–13

Mycologia 82:142, 1990; III, on *Melicope anisata* (mokihana). BISH 612837, 1991.

This rust fungus was previously known only from a meager herbarium specimen, tentatively designated *Xenostele* sp., collected on *Pelea* sp. in Mākaha Valley, O'ahu (Gardner and Hodges 1989). *Pelea* is now considered a synonym of *Melicope* (Wagner et al. 1990). The rust subsequently was recognized as a new species and described under its current name (Gardner 1990). Fresh material also was found near Kōke'e State Park, Kaua'i, on *M. anisata,* a species endemic to Kaua'i (Plate 11). Older infections also were found in the same vicinity on *M. ovata* and *M. peduncularis,* both of which are endemic to Hawai'i (TF 5562) (Wagner et al. 1990). Currently this fungus is considered

endemic, because no records were found of a similar rust on rutaceous hosts elsewhere (Gardner 1994*a,b*). However, its initial discovery on an unidentified species of *Melicope* on O'ahu indicates that its host range on species of *Melicope* and its distribution throughout the Islands are not yet known. Like *P. rugispora,* which also occurs on Rutaceae in the Kōke'e region of Kaua'i, *P. rutainsulara* is microcyclic, represented by only the telial state, and is distinctive in producing tightly compacted columns of teliospores that are forcibly exuded from deep-seated, pitlike telia (Plate 12). Teliospores germinate to produce a basidium bearing a single basidiospore (Plate 13), in contrast to the series of four basidiospores typical of most rust fungi. Nuclear behavior accompanying these events varies from behaviors usually considered normal for the Uredinales, providing a further example of developmental diversity in an isolated insular environment (Gardner 1994*b*).

Puccinia senecionicola Arth.

Bot. Gaz. 40:199, 1905; II, on *Crassocephalum crepidioides.* BISH 590219, 1990.

The host is a common herbaceous weed of the Asteraceae native to tropical Africa and now naturalized througout the Eastern Hemisphere. It is also naturalized and widely distributed in Hawai'i, having been first recorded in 1929, where it is recognized by its bright reddish orange florets (Wagner et al. 1990, Wester 1992). Lower leaves of plants on the Mānoa Cliffs Trail in the Ko'olau Mountains of O'ahu were moderately to heavily infected with the rust, previously known from species of *Cacalia* and *Senecio* in Mexico and tropical America (Cummins 1978). Although only the uredinial state is known in Hawai'i currently, the rust probably is more widely distributed. Eventual discovery of the telial state is considered likely.

Puccinia striiformis var. *striiformis* Westend.

Bull. R. Acad. Belg., Cl. Sci. 21:235, 1854; II and III, on *Vulpia* sp. (fescue). TF4560, 1991.

Puccinia striiformis var. *striiformis,* known to be geographically widely distributed on a large number of grass genera (Cummins 1971), is conspicuous by production of bright orange-yellow uredinia in linear patterns mostly on the undersurfaces of leaves. It was collected on fescue grass at Waimea Canyon, Kaua'i, and its occurrence in Hawai'i is probably not uncommon. *Puccinia striiformis* var. *striiformis* is distinct from *P. striiformis* var. *dactylidis* Manners, reported previously on *Dactylis glomerata* (orchardgrass) (Gardner and Hodges 1989). *Puccinia striiformis* var. *dactylidis* reportedly is limited to *D. glomerata.* It is further distinguished by production of smaller spores and tolerance of higher environmental temperatures than are characteristic of *P. striiformis* var. *striiformis* (Cummins 1971).

Uredo artocarpi B. & Br.
Plate 14

Fungi of Ceylon, no. 832, (no date); II, on *Artocarpus altilis* (breadfruit). BISH 612842, 614103, 1990–1991.

Breadfruit rust has long been known on species of *Artocarpus* from India, the Philippines, and islands of the South Pacific. Although breadfruit rust has been documented in Hawai'i relatively recently (Gardner 1991*b*), its discovery on the widely separated islands of Kaua'i and Hawai'i indicates that it has been in Hawai'i considerably longer and is probably distributed throughout the Islands. As is characteristic of the form-genus *Uredo, U. artocarpi* is known from only the uredinial state. The disease produces small, irregularly necrotic leaf spots, visible on both surfaces, which in heavy infections may coalesce to give a russeted appearance associated with premature leaf fall (Plate 14). However, the disease appears to have minimal effect on the tree itself, and the inconspicuously minute uredinia are easily overlooked by the casual observer.

Uredo myopori Cumm.
Plate 15

Bull. Torrey Bot. Club 79:232, 1952; II, on *Myoporum sandwicense* (naio). BISH 548135–6, 614106–7, 1989, 1991.

Uredo myopori was first collected in 1946 on naio at Parker Ranch on the island of Hawai'i

and deposited at the Arthur Herbarium of Purdue University. The rust was formally described as a new species in 1952, along with a heterogeneous assortment of other new rusts from various regions of the world (Cummins 1952). *Uredo myopori* remained unknown to scientists in Hawai'i until fresh material was rediscovered in 1989 in Hawai'i Volcanoes National Park (Gardner 1989) (Plate 15). To date naio rust is known only from *M. sandwicense* on the island of Hawai'i, and, because no similar rust has been reported on *Myoporum* hosts elsewhere, it is presently considered endemic to Hawai'i (Gardner 1989, 1994*a*).

In addition to the above compilation of recently discovered rusts, the following observations are worthy of note:

Puccinia porri Wint. was reported on *Allium ascalonicum* (shallot) and *A. fistulosum* (green onion) in Hawai'i (Raabe et al. 1981). No specimens are known to be on deposit.

Pucciniastrum vaccinii (Wint.) Jørst., a species on *Vaccinium* spp. elsewhere and represented in Hawai'i by only the uredinial state (Gardner and Hodges 1989), is notable as one of the few examples of an introduced rust attacking an endemic species, *V. reticulatum.* Expansion of the host range of *P. vaccinii* to a second endemic species of *Vaccinium, V. calycinum* (tree 'ōhelo), in Hawai'i Volcanoes National Park, is newly reported here (BISH 612838, 1991).

Uredo vulcani Gardner, listed as a recently discovered endemic species on *Coprosma rhynchocarpa* (pilo) (Gardner and Hodges 1989), was known only from certain trees in Kīpuka Puaulu, Hawai'i Volcanoes National Park on the island of Hawai'i (Gardner 1988). This rust has more recently been found on *C. waimeae* ('ōlena) on the Awa'awapuhi Trail and in Mākaha Valley of Kaua'i (TF 4585, 4669), new island and host records. The discovery of this rust on different species of *Coprosma* on widely separated islands indicates it to be more widely distributed than was at first recognized. Uredinial pustules are minute and occur on the undersurfaces of infected leaves (Plate 16), where they may be easily overlooked.

Uromyces alyxiae Arth. in Stevens occurs on *Alyxia oliviformis* (maile) in Hawai'i (Plates 17, 18, 21, 22), where both the host and the fungus are considered endemic. However, a rust obviously closely related to the Hawaiian form was found recently in the Bunya Mountains of Queensland, Australia, on *A. ruscifolia,* a host endemic to that region. Morphologically, these rusts differed slightly from one another in the larger teliospores of the Australian form (Plate 19), which were produced in larger, individual telia (Plate 20), as compared with the smaller spores and clustered telia of the Hawaiian form (Plates 21, 22). Based on the apparent similarities, the Australian rust was described as *U. alyxiae* var. *australiensis* Tierney & Gardner (PUR 89656, holotype; BRIP 17158, isotype) (Tierney and Gardner 1992). The obvious alliance of rusts from Hawai'i and Australia is of particular biogeographical interest and suggests the likelihood that similar rusts remain to be found on *Alyxia* spp. elsewhere in the Pacific.

Older rust specimens are on deposit at BISH under binomials that have since been reduced to synonymy but that retain the original names. Many of these have been updated (Gardner and Hodges 1989), but others are noted as follows:

Puccinia panicicola Arth. collected on *Panicum molle* (para grass) in 1913 now is considered synonymous with *Uromyces setariaitalicae* Cumm. (Cummins 1971), the uredinial state of which also occurs commonly on *Brachiaria mutica* (California grass) in Hawai'i.

Puccinia clematidis (DC) Lagerh. on *Triticum* sp. (wheat) collected in 1910 now is included in the *P. recondita* complex (Cummins 1971).

A rust on *Abutilon molle* collected in 1940 as *P. anomela* (no author given) is actually *P. heterospora* Berk. & Curt.

Tranzschelia discolor (Fuckel) Tranz. & Litv. was earlier erroneously listed to occur on *Chrysobalanus icaco* (coco plum) in Hawai'i (Gardner and Hodges 1989); however, this rust has been confirmed only on the genus *Prunus.*

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